What is claimed is:

1. A diffraction device for periodically dividing an electromagnetic wave, the diffraction device comprising:

a diffraction grating;

an input medium contacting the diffraction grating; and

an output medium contacting the diffraction grating,

with at least either one of the input medium and output medium comprising a photonic crystal having a periodic characteristic in single direction, or the diffraction grating comprising a photonic crystal, which periodically divides electromagnetic waves to produce a phase difference in a wave front with differences in optical propagation distances between the divided electromagnetic waves.

2. The diffraction device according to claim 1, wherein the photonic crystal satisfies the condition of

$$2 \leq \left| (\Delta\lambda / \lambda_0) / (\Delta\omega / \omega_0) \right|,$$

whereas λ_0 represents the wavelength of a propagating wave when an electromagnetic wave having frequency ω_0 propagates in a specific direction in the photonic crystal, and $\Delta\lambda$ represents the change of wavelength relative to an electromagnetic wave having frequency $\Delta\omega+\omega_0$ when the frequency ω_0 is changed by a slight amount.

3. The diffraction device according to claim 1, wherein the photonic crystal includes a periodic direction and said at least either one of the input medium and the output medium comprising the photonic crystal, includes end surfaces perpendicular to the periodic direction of the photonic crystal as an input surface and an output surface, the photonic crystal includes a photonic band gap and a photonic band in the vicinity of the photonic band gap, and

the electromagnetic waves entering the input surface are propagated by the photonic band.

4. The diffraction device according to claim 1, wherein the photonic crystal includes end surfaces from which the periodic characteristic is exposed as an input surface and an output surface, a photonic band structure having a line, which is ether a Brillouin zone boundary line or a central line, and a photonic band, and electromagnetic waves entering the input surface are propagated by one of:

the photonic band, which exists on the Brillouin zone boundary line of the photonic band structure or in the vicinity of the Brillouin zone boundary line; and

the photonic band, which exists on the central line of the photonic band structure or in the vicinity of the central line.

5. The diffraction device according to claim 4, wherein the photonic crystal includes an end surface parallel in the periodic direction of the photonic crystal as an input surface and an output surface, the photonic crystal including a period, the diffraction device further comprising:

an input phase modulating unit for generating a phase modulation wave having a period that is the same as or two times the period of the photonic crystal, wherein the input phase modulating unit is arranged contacting, near, or integrally with the input surface.

6. The diffraction device according to claim 5, wherein the phase modulating unit is a phase grating having a period that is the same as or two times the period of the photonic crystal.

7. The diffraction device according to claim 4, wherein the photonic crystal outputs wave, the diffraction device further comprising:

an output phase modulating unit for converting the light output from the photonic crystal to a plane wave, with the output phase modulating unit arranged contacting, near, or integrally with the output surface.

8. The diffraction device according to claim 4, wherein the photonic crystal has a periodic direction and an inclined input surface or inclined output surface that is inclined relative to the periodic direction of the photonic crystal, and inputs a plane wave to the inclined input surface or outputs a plane wave from the inclined output surface.

9. The diffraction device according to claim 1, wherein the photonic crystal has an end surface, which includes a reflective diffraction grating that comprises said diffraction grating, and when electromagnetic waves including plural frequency components are input to the photonic crystal, the reflective diffraction grating produces diffracted wave for each of the plural frequency components of the electromagnetic wave in different directions.

10. The diffraction device according to claim 9, the diffraction device may be used with an electromagnetic wave detector and the photonic crystal includes a periodic direction and the input medium and the output medium both comprise the photonic crystal and form a waveguide having an input surface and end surface parallel to the periodic

direction of the photonic crystal, with the reflective diffraction grating comprising a blazed reflective diffraction grating arranged in the end surface of the waveguide, and the diffraction device forming a demultiplexer for outputting electromagnetic waves, which include plural frequency components input from the input surface of the waveguide, with the blazed reflective diffraction grating from the input surface as diffraction waves in different directions for each frequency component to couple the electromagnetic waves with the electromagnetic wave detector or the waveguide.

11. The diffraction device according to claim 10, further comprising:

a lens element having a convex lens effect to input the electromagnetic waves including plural frequency components to the input surface of the waveguide as parallel light bundle, wherein electromagnetic waves output from the waveguide are collected by the lens element and coupled with the electromagnetic wave detector when used therewith or the waveguide.

12. The diffraction device according to claim 10, wherein the input surface of the waveguide comprises a convex lens-like input surface, with the electromagnetic waves including plural frequency components being input to the waveguide as a parallel light bundle produced by the convex lens-like input surface, and collected light bundle produced by the input surface of the convex lens-like surface from the electromagnetic wave output from the photonic crystal in different directions for each frequency component coupled with the electromagnetic wave detector when used therewith or the waveguide.

13. The diffraction device according to claim 10, wherein the blazed reflective diffraction grating has a concave mirror-like diffraction grating surface and collects electromagnetic waves separated into frequency components with the concave mirror-like diffraction grating surface and outputs the collected electromagnetic waves from the waveguide.

14. The diffraction device according to claim 10, wherein the waveguide is a slab waveguide.

15. The diffraction device according to claim 10, wherein the photonic crystal includes a period, the diffraction device further comprising:

an input phase modulating unit for generating a phase modulation wave having a period that is the same as or two times the period of the photonic crystal, wherein the input phase modulating unit is arranged contacting, near, or integrally with the input surface of the waveguide.

16. The diffraction device according to claim 15, wherein the input phase modulating unit is a phase grating having a period that is the same as or two times the period of the photonic crystal.

17. The diffraction device according to claim 1, further comprising:

an array waveguide diffraction grating including an input slab waveguide connected to the input waveguide, an output slab waveguide connected to output waveguide, and an arrayed waveguide connected between the two slab waveguides and generating an optical path length difference, with the

arrayed waveguide comprised of the photonic crystal as the diffraction grating that periodically divides electromagnetic waves and produces a phase difference in the wave fronts of the divided electromagnetic waves.

18. The diffraction device according to claim 17, wherein the arrayed waveguide includes a plurality of waveguides, each comprised of the photonic crystal, and adjacent waveguides have different lengths.

19. The diffraction device according to claim 17, wherein the arrayed waveguide includes a plurality of waveguides, each comprised of the photonic crystal with adjacent waveguides having the same length, and by changing the period, material, or configuration of the photonic crystal comprising each of the waveguides, an optical path length difference is produced between adjacent waveguides.

20. The diffraction device according to claim 17, wherein the input waveguide, the input slab waveguide, and the arrayed waveguide each have an input surface, the diffraction device further comprising:

an input phase modulating unit for generating a phase modulating wave having a period that is the same or two times the period of the photonic crystal configuring the arrayed waveguide, with the phase modulating unit arranged contacting, near, or integrally with one of the input surface of the input waveguide, the input surface of the input slab waveguide, and the input surface of the arrayed waveguide.

21. The diffraction device according to claim 17, wherein the output waveguide, the output slab waveguide, and

the arrayed waveguide each have an output surface, the diffraction device further comprising:

an output phase modulating unit for converting wave output from the arrayed waveguide to a plane wave, with the output phase modulating unit arranged contacting, near, or integrally with one of the output surface of the output waveguide, the output surface of the output slab waveguide, and the output surface of the arrayed waveguide.

22. The diffraction device according to claim 17, the photonic crystal includes a period and the phase modulating unit is a phase grating having a period that is the same or two times the period of the photonic crystal configuring the arrayed waveguide.

23. The diffraction device according to claim 1, wherein the photonic crystal comprises a multilayer body in which dielectric bodies having different refractive indices are superimposed in periods that are about the same as the wavelength of light.